Geologic Sequestration Overview: Fundamentals and Regional Issues

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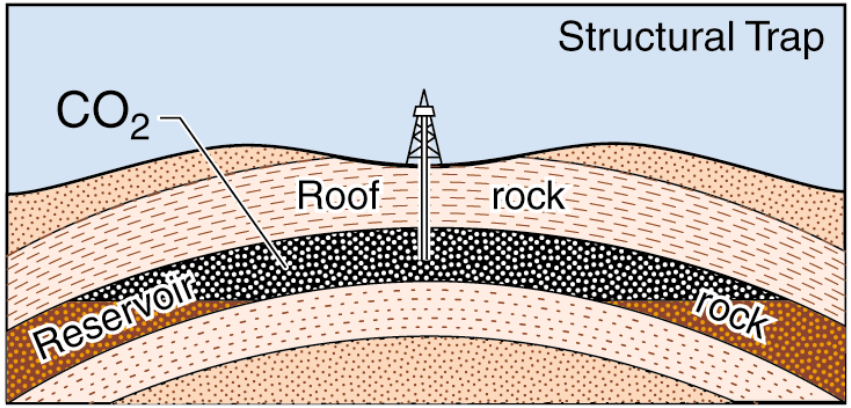
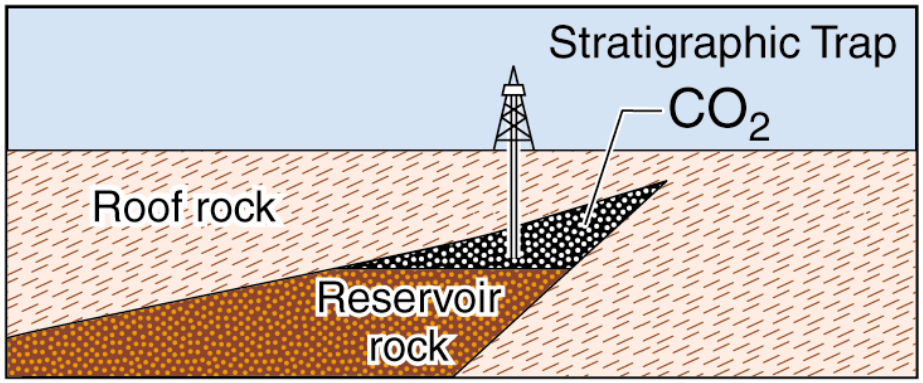
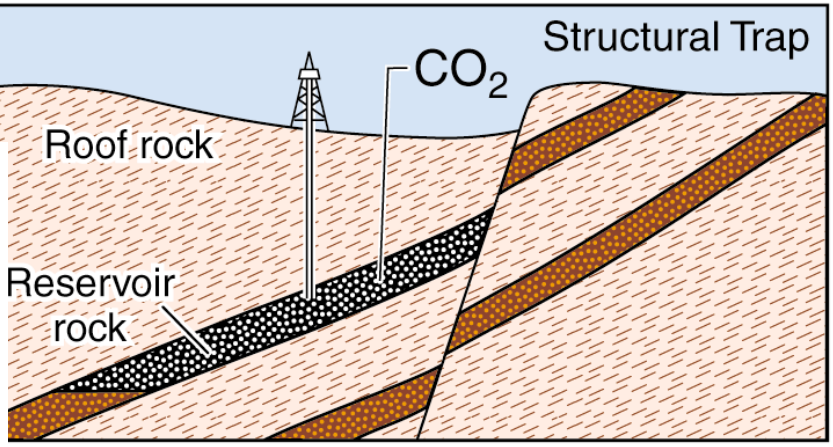
Geologic Storage Mechanisms

- **CO_2 is stored in the subsurface by a combination of physical and chemical processes**

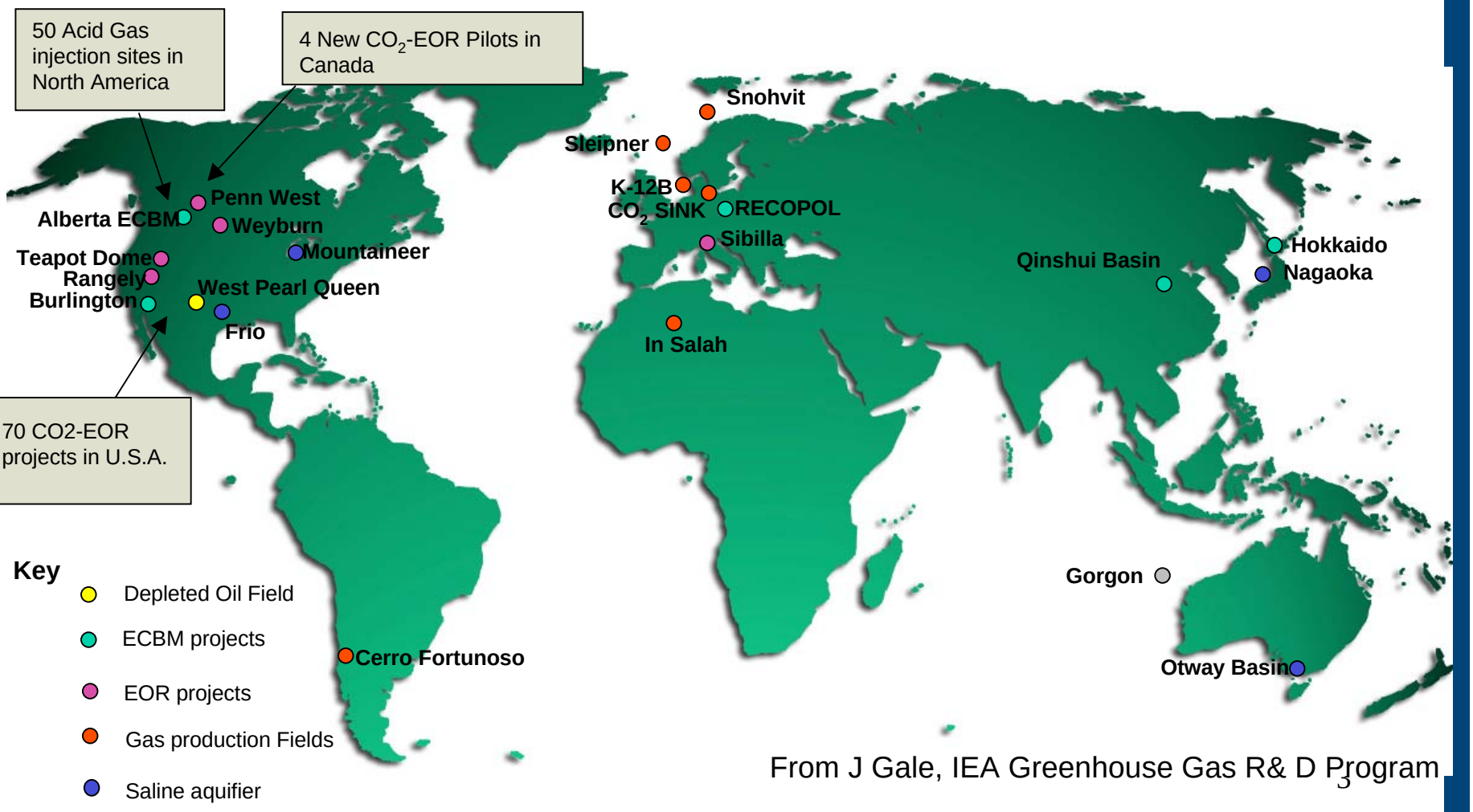






Typical geological structures ideal for trapping CO_2 (Source: W Gunter, ARC)

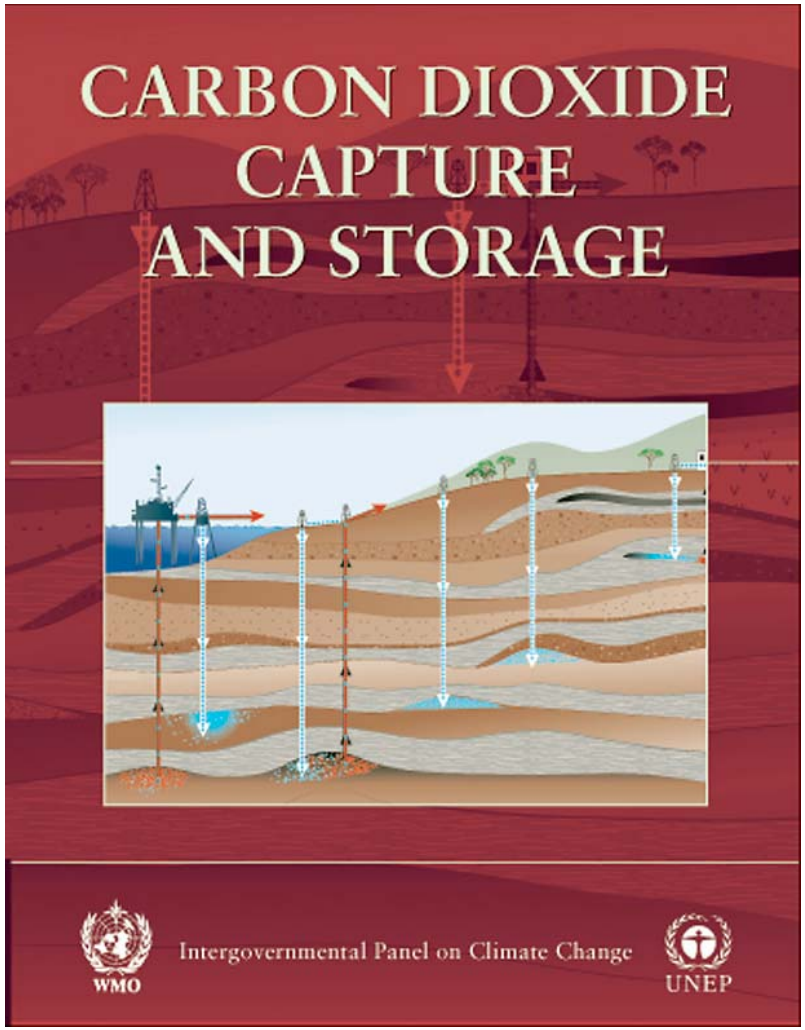
CO_2 Injection and Storage Activities



From J Gale, IEA Greenhouse Gas R& D Program

International Consensus on Geologic Sequestration Issues Provided by IPCC Report

- Over 125 contributing scientists
- Availability of sinks, capacity
- Technology readiness
- Costs
- Risks
- Monitoring
- Remediation



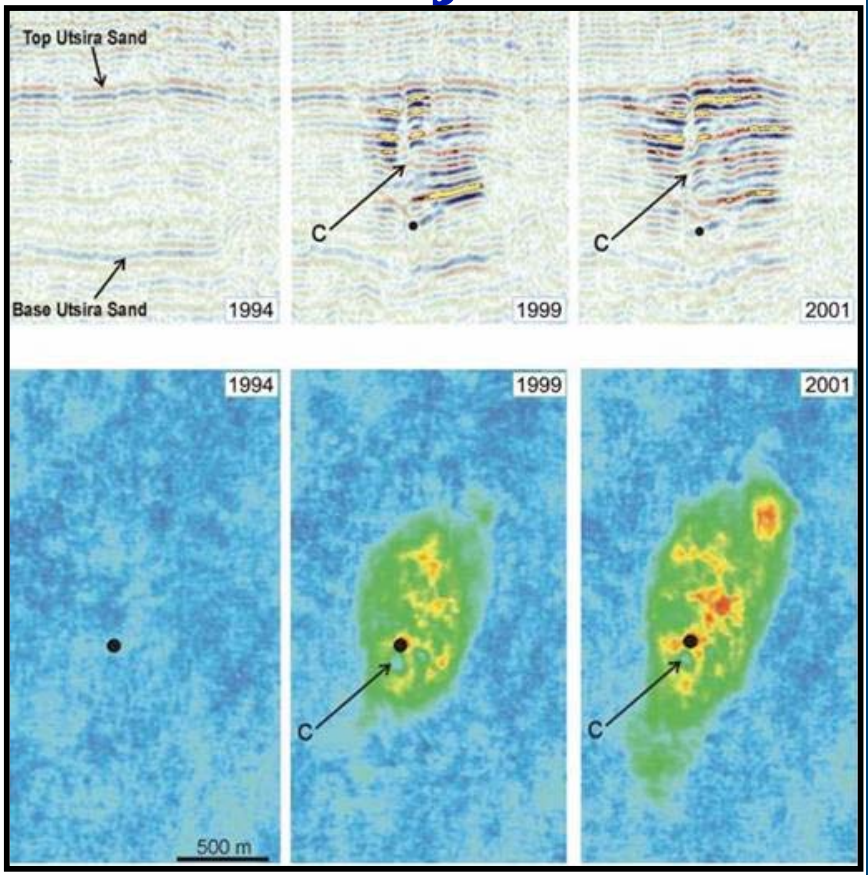
Risks of Geologic Storage Studied Extensively

- **Impacts of unintended leakage**
  - Health and safety of workers and general population
  - Environmental impacts
  - Unwanted intrusion into drinking water
- **Earthquakes**
- **Unwanted intrusion of saline fluids**

" With appropriate site selection informed by available subsurface information, a monitoring program to detect problems, a regulatory system, and the appropriate use of remediation methods to stop or control CO_2 releases if they arise, the local health, safety, and environment risks of geological storage would be comparable to risks of current activities such as natural gas storage, EOR, and deep underground disposal of acid gas." IPCC, 2005

Monitoring will be a Key Element of Geologic Sequestration Projects

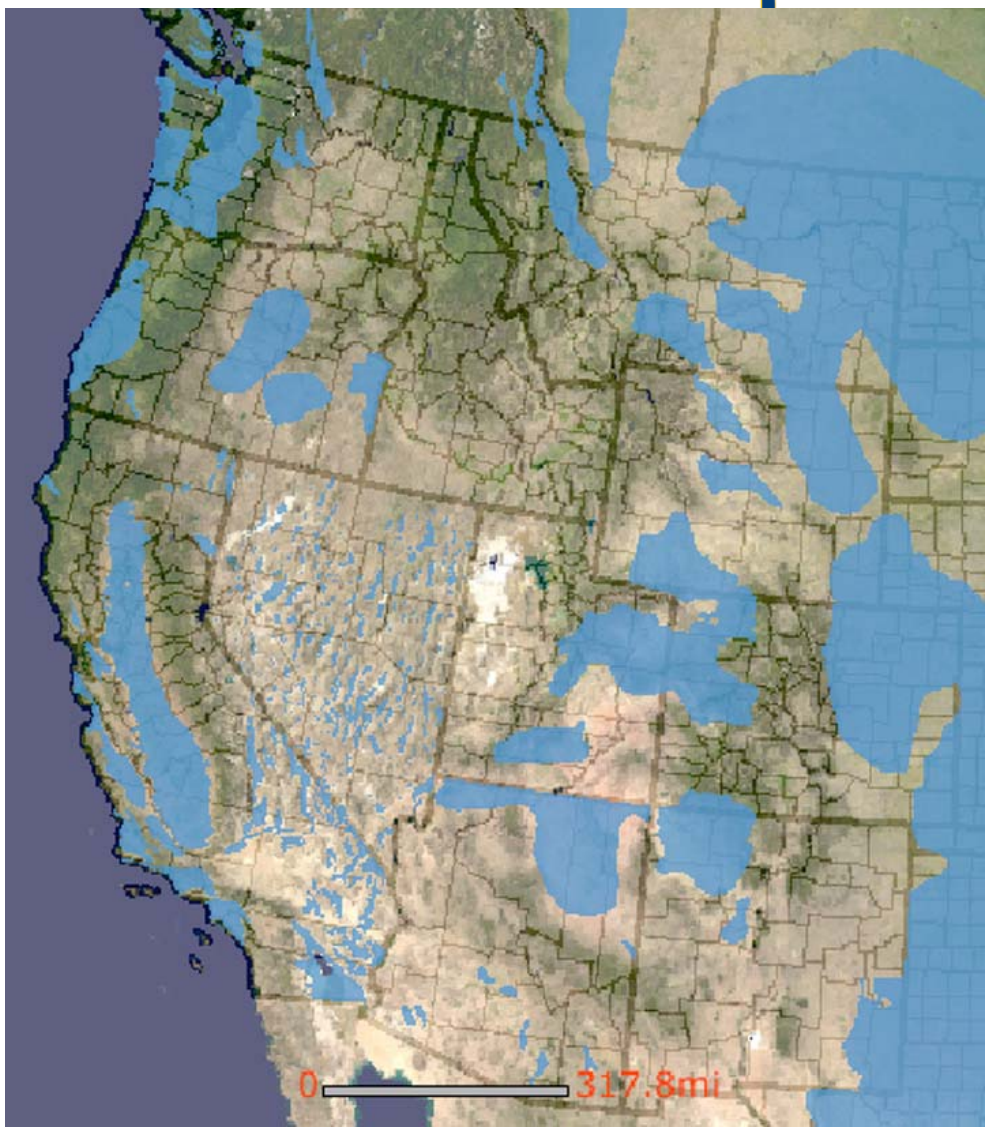
- **Sophisticated geophysical technologies, directly applicable to geologic sequestration, have been developed in oil and gas industry**
- **Additional approaches should, and are, being developed**
- **Cost of monitoring over the operational life of a project using current technology on the order of ~$0.10/ton CO_2**



Time-lapse seismic monitoring results from Sleipner, after Chadwick et al., 2005

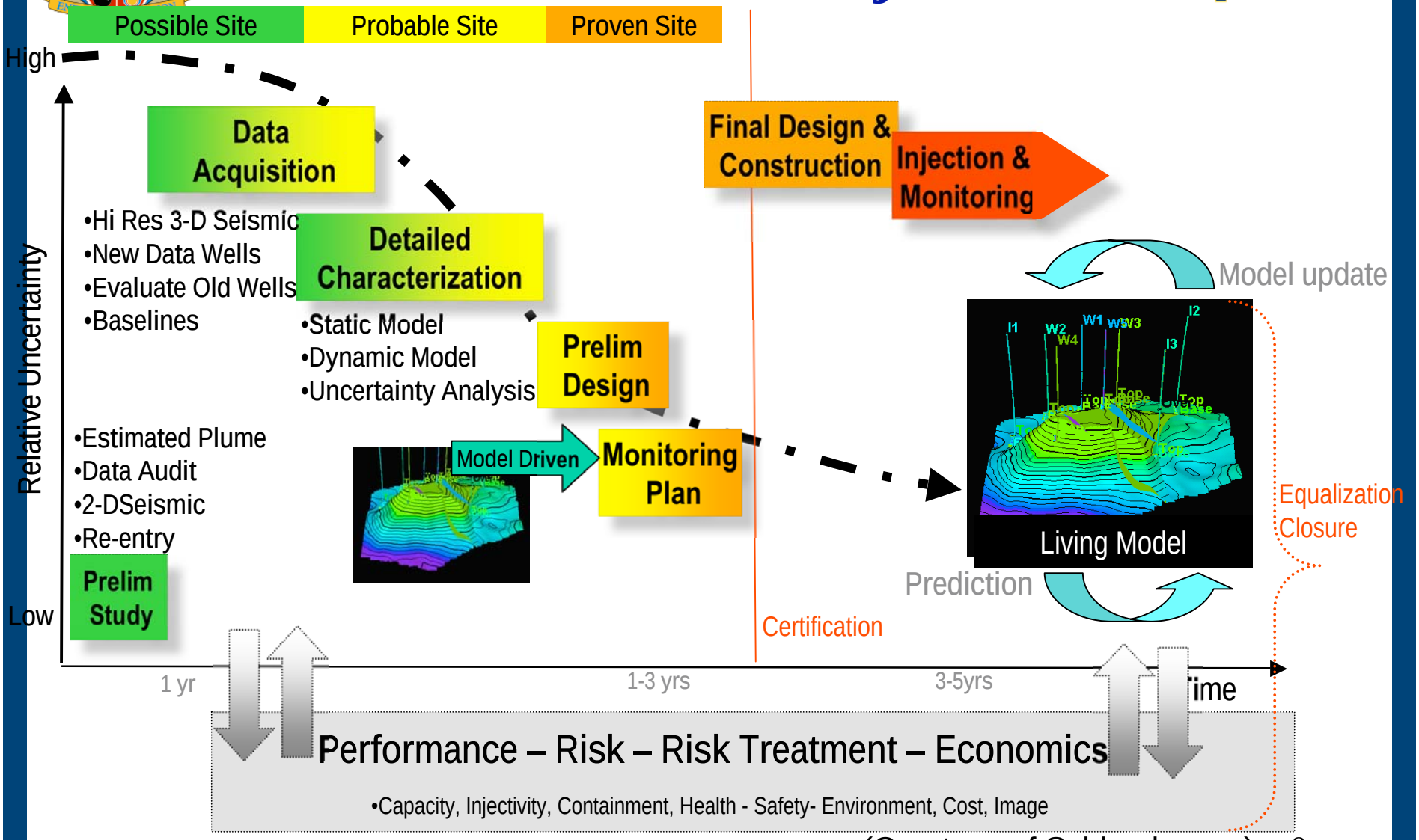
Potential Storage Capacity is Very Large

- **Good storage sites are not uniformly distributed**
- **Some of the best early opportunities may be in California**



Saline formations in the western US (From DOE NATCARB)

Proposed Framework for Commercial Projects



(Courtesy of Schlumberger)

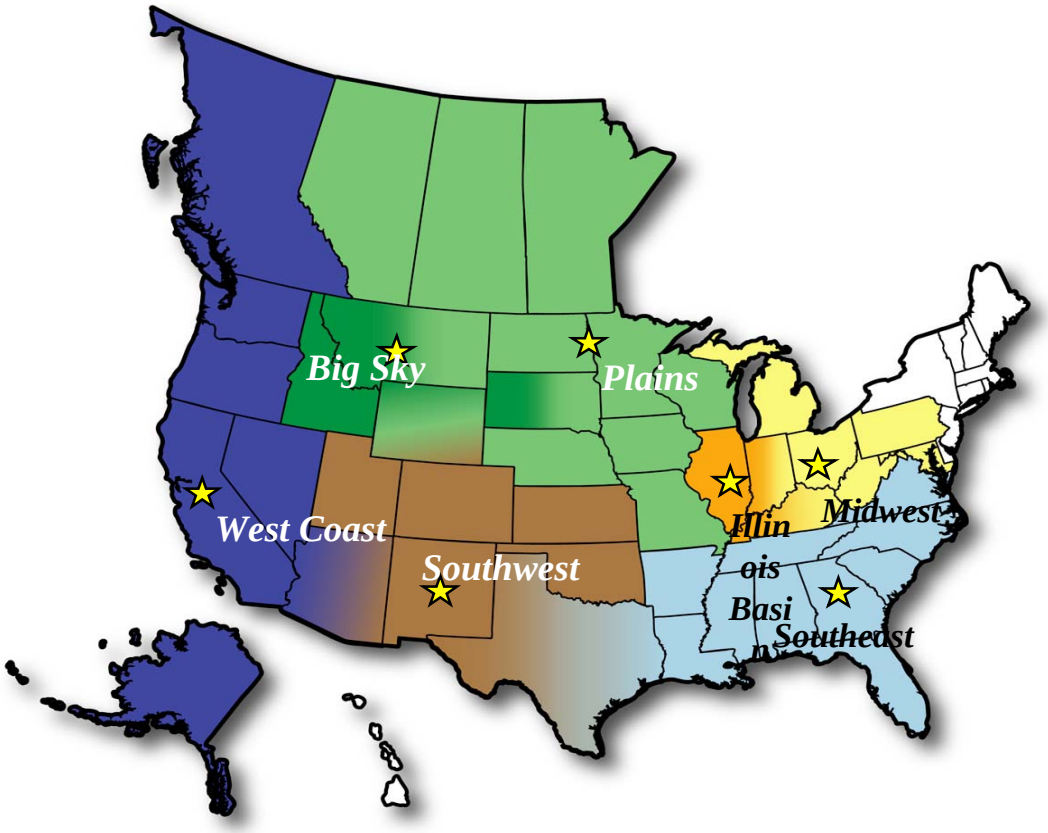
Field Tests Provide Regional Knowledge Base Essential for Implementation

- **Testing technologies**
  - EOR, EGR, saline formation storage
- **Assessing capacity**
- **Defining costs**
- **Assessing leakage risks**
- **Gauging public acceptance**
- **Exercising regulatory requirements**
- **Validating monitoring methods**

Photos from Frio saline formation CO_2 injection test

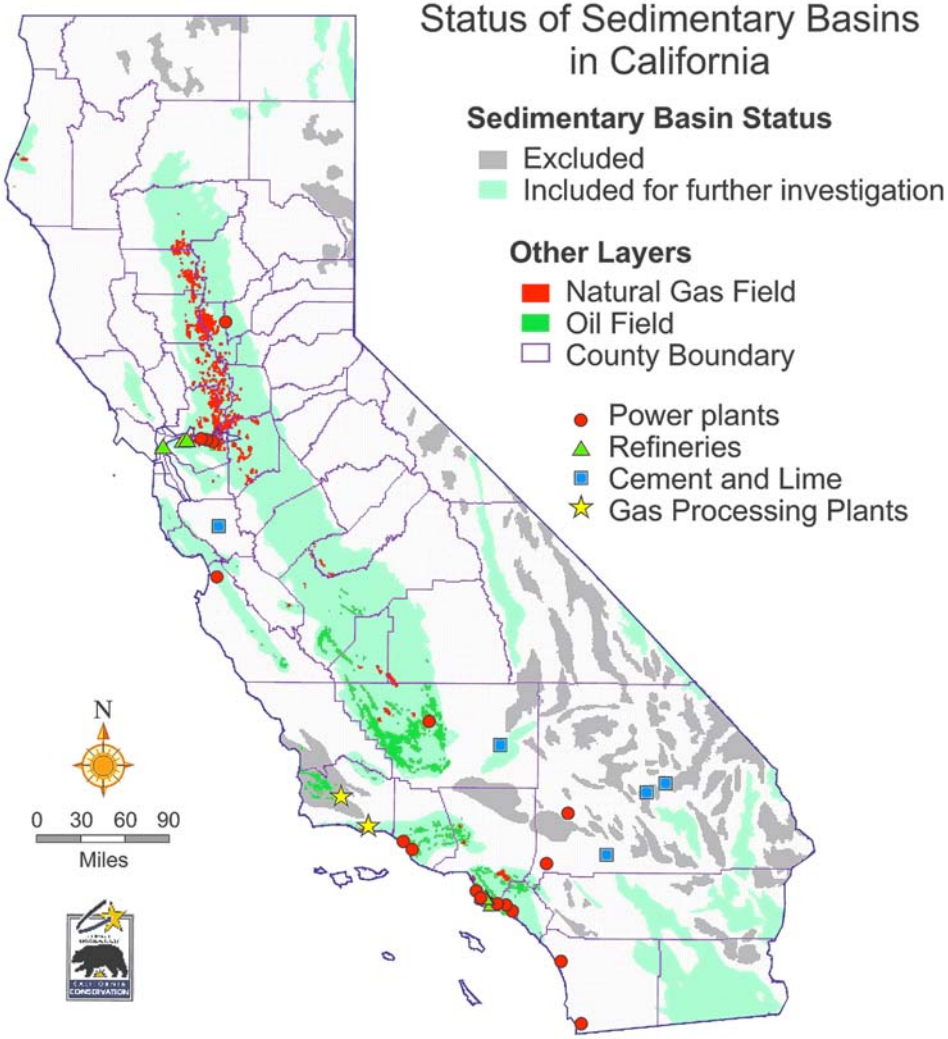
US DOE Regional Partnership Program Addresses Implementation Issues

- Over 350 participating organizations in U. S, and Canada
- Phase I (complete): focus on regional assessments
- Phase II (underway): focus on pilot studies
- Phase III (coming): large volume geologic field tests

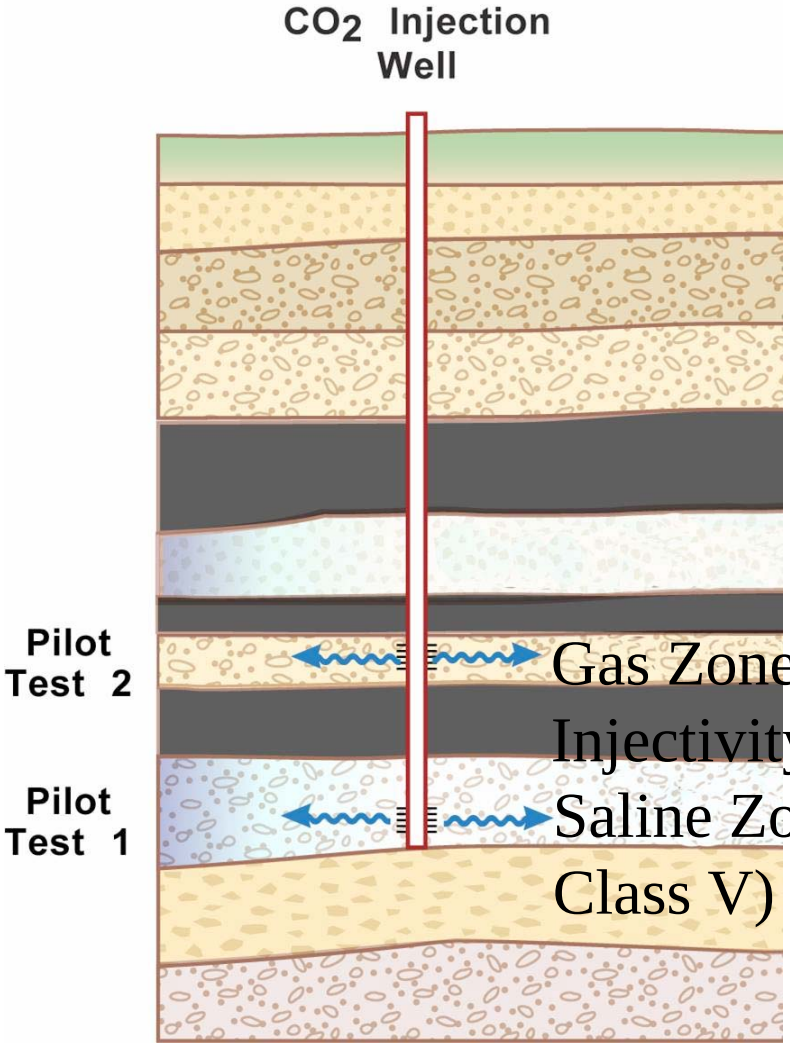


WESTCARB Field Tests are Located in the Central Valley

- Central valley has huge potential storage capacity, also potential EOR and EGR
- Phase II pilot in southern Sacramento basin and Phase III large volume test in southern San Joaquin basin



Pilot Tests Help Establish Regulatory and Legal Frameworks

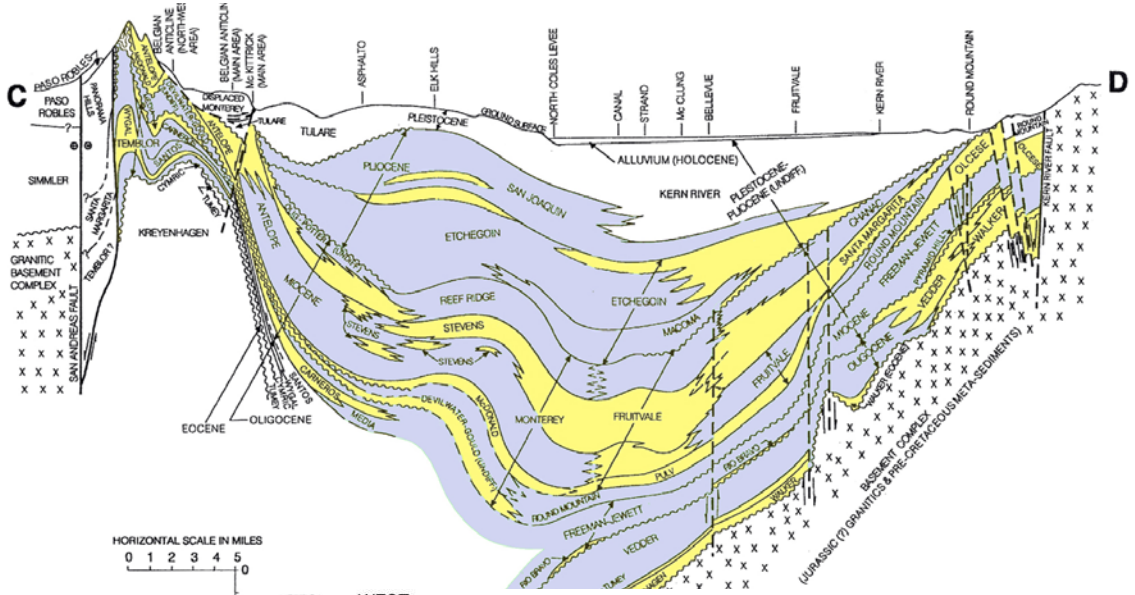


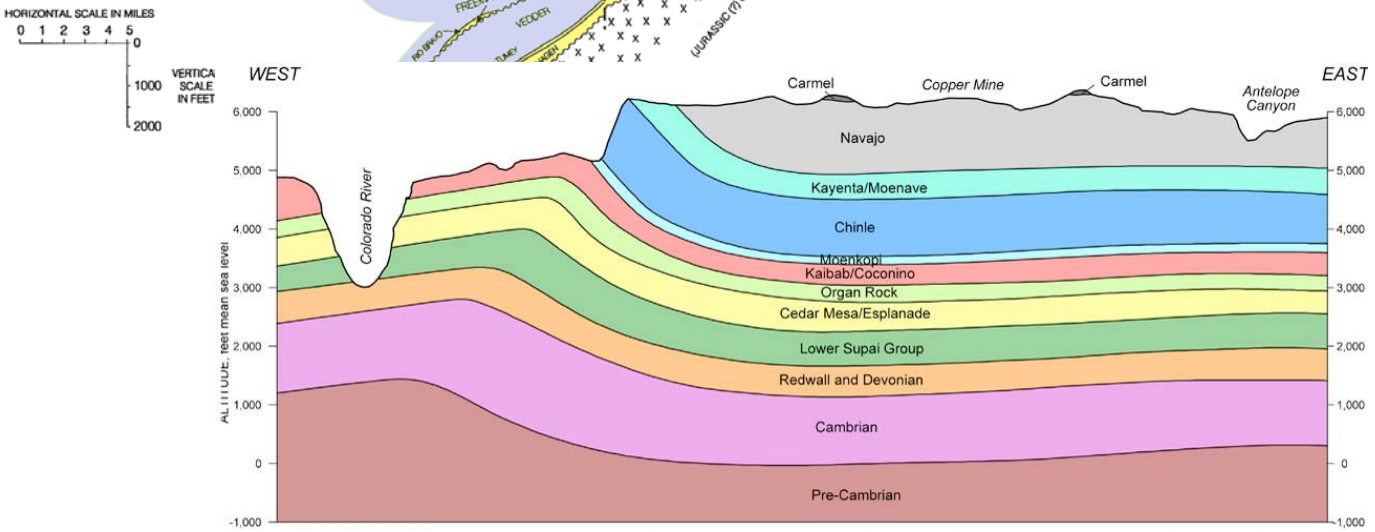
- **Regulatory authority**
- **Mineral rights**
- **Land access agreements**

Gas Zone—CA DOGGR (Short-term Injectivity Test)

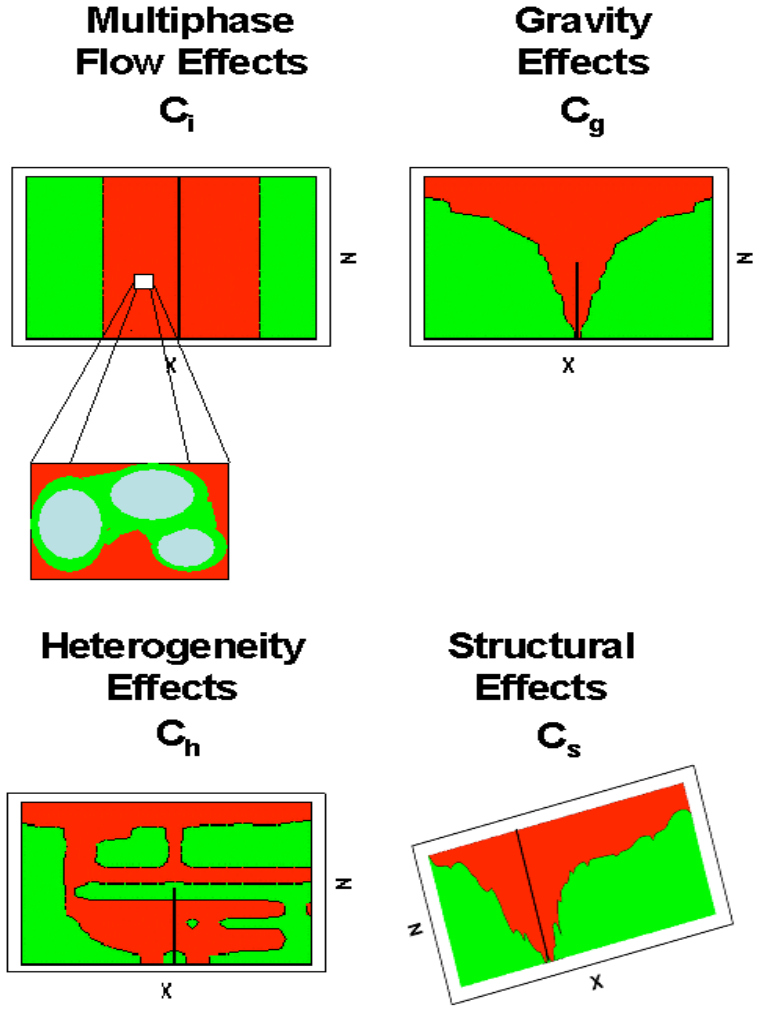
Saline Zone—U.S. EPA Region 9 (UIC Class V)

Regional Geologic Settings Vary





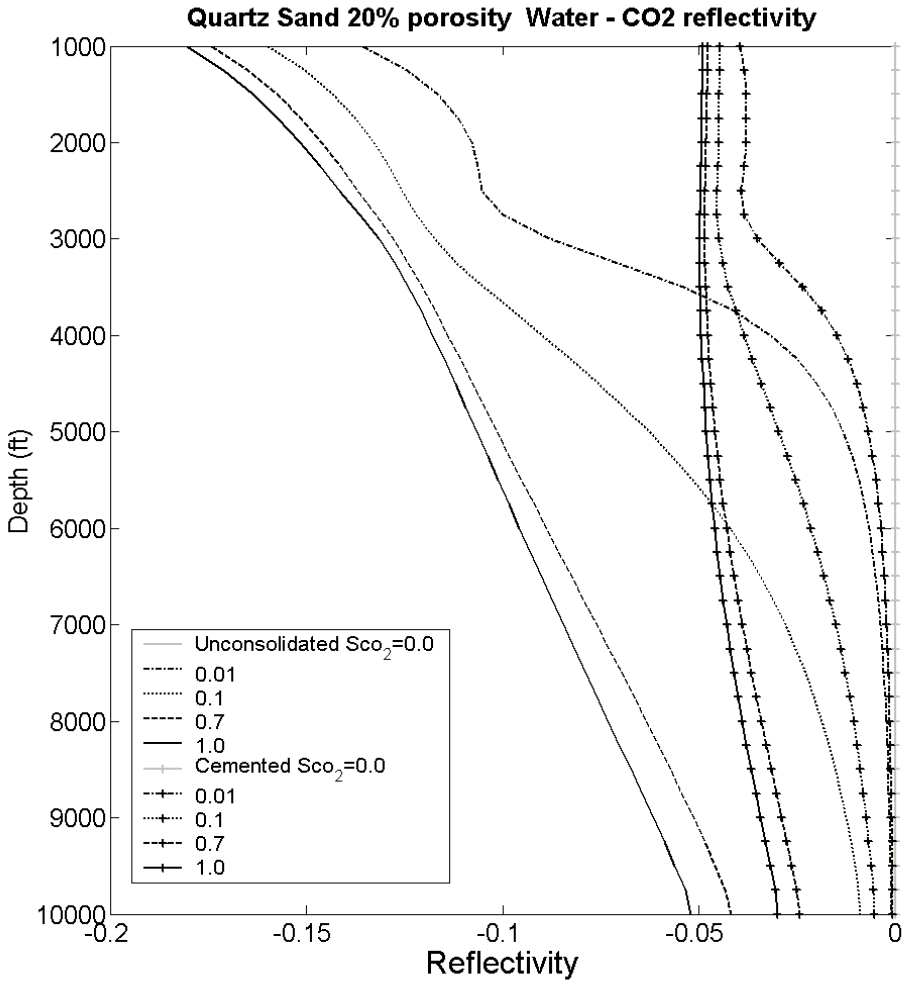
What is the Storage Capacity of Potential Projects in the Central Valley?



- Two phase flow properties, geologic heterogeneity, compartmentalization, etc affect storage capacity
- Directly relates to project design
- Uncertainty in predictions reduced by field tests

Will Seismic Techniques Work Everywhere?

- **Structural complexity, rock properties, lithology, surface conditions, presence of gas, etc, affect seismic response**
- **Uncertainty in predictions decreased by field tests**



Modeled reflectivity of a CO_2 layer in unconsolidated and consolidated rock

Summary

- General consensus in the scientific community of the technical viability of geologic storage
- A large amount of technical expertise already exists
- Field tests provide information essential for answering remaining questions specific to implementation in California